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PROCEDURE FOR INSPECTION AND TESTING OF LIGHT METALS (ALUMINIUM AND MAGNESIUM) AND THEIR ALLOY INGOTS AND CASTINGS FOR AIRCRAFT PURPOSES

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PROCEDURE FOR INSPECTION AND TESTING OF LIGHT METALS (ALUMINIUM AND MAGNESIUM) AND THEIR ALLOY INGOTS AND CASTINGS FOR AIRCRAFT PURPOSES

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Indian Standard

PROCEDURE FOR INSPECTION AND TESTING OF LIGHT METALS (ALUMINIUM AND MAGNESIUM) AND THEIR ALLOY INGOTS AND CASTINGS FOR AIRCRAFT PURPOSES

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 20 December 1962, after the draft finalized by the Light Metals and Their Alloys Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 As indigenous raw materials for aircraft production have assumed great importance and the production of aircraft in the country has already commenced, Light Metals and Their Alloys Sectional Committee decided to formulate this specification which will help in ensuring the quality of aircraft materials.

0.3 Taking into consideration the views of producers, consumers and testing authorities, the Sectional Committee responsible for the preparation of this standard felt that it should be related to the manufacturing and trade practices followed in the country in this field. Furthermore, due weightage had to be given to the need for international co-ordination among standards prevailing in different countries of the world. These considerations led the Sectional Committee to derive assistance from B.S. 2L.101 : 1959 Inspection and Testing Procedure for Aircraft Material, Aluminium-Base and Magnesium-Base Ingots and Castings issued by the British Standards Institution.

0.4 Wherever a reference to any Indian Standard appears in this specification, it shall be taken as a reference to the latest version of the standard.

0.5 This standard is one of a series of Indian Standards on aluminium and its alloys for aircraft purposes. Other standards in this series are:

*IS : 23-1959 SPECIFICATION FOR 99 PERCENT PRIMARY ALUMINIUM NOTCHED BARS AND INGOTS FOR REMELTING FOR AIRCRAFT PURPOSES (*Revised*)

†IS : 30-1953 SPECIFICATION FOR ALUMINIUM-COATED HIGH-TENSILE ALUMINIUM ALLOY SHEETS AND COILS FOR AIRCRAFT PURPOSES

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*Since revised.

†Since withdrawn.

*IS : 202-1960 SPECIFICATION FOR ALUMINIUM ALLOY INGOTS AND CASTINGS FOR AIRCRAFT PURPOSES (*Revised*)

†IS : 1847-1961 SPECIFICATION FOR 99·7 PERCENT PRIMARY ALUMINIUM NOTCHED BARS AND INGOTS FOR REMELTING FOR AIRCRAFT PURPOSES

0.6 Metric system has been adopted in India and all quantities and dimensions in this standard have been given in this system.

0.7 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960 Rules for Rounding Off Numerical Values (*Revised*). The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

0.8 This standard is intended chiefly to cover the technical provisions relating to inspection and testing of the material, and it does not include all the necessary provisions of a contract.

1. SCOPE

1.1 This standard covers the general inspection and testing requirements for aircraft quality light metal ingots and their alloy ingots for re-melting purposes and castings.

PART I GENERAL REQUIREMENTS

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Cast — A ' Cast ' shall be defined as one of the following:

a) The product of one furnace melt;
b) The product of one crucible melt;
c) The product of a number of crucible or furnace melts mixed prior to castings;
d) The amount of metal tapped from the furnace without any further addition having been made, when a continuous melting process is employed for the production of ingots; and
e) The amount of metal which may be represented by one tensile test sample when die castings are produced from continuously fed melting units.

---

*Since revised.

†Since withdrawn and superseded by IS : 23.

2.2 Inspector — This term shall be interpreted in the manner directed by the Indian Air-Worthiness Authority, if the material is intended for aircraft purposes. In other cases, ' Inspector ' shall mean a person or persons expressly authorized in writing by the purchaser to act on his behalf for inspection of the material.

2.3 Approved Scrap — Scrap which arises from the ingot maker's own production to the relevant Indian Standard, or from the founder's own production from approved ingots, and which is segregated and identified to the satisfaction of the inspector. It may include headers, runners and heavy fettling scrap, but shall exclude all small particles.

2.4 Approved Ingots — The term ' approved ingots ' denotes aluminium or magnesium alloy ingots which have been proved to comply with the relevant clauses of the material specification regarding both analytical and mechanical test requirements.

3. QUALITY OF MATERIAL

3.1 The material shall conform to the relevant specification.

3.2 Apart from the requirements given in this standard, the specific requirements as specified in the relevant material specifications shall also be complied with.

4. CHEMICAL COMPOSITION

4.1 The chemical composition of the ingots and castings shall comply with the relevant specification.

5. TEST SAMPLES FOR CHEMICAL ANALYSIS

5.1 Except when otherwise provided in the specification, from each cast, as defined in **2**, an analytical sample or samples shall be prepared and suitably marked so ensure identification. Unless special samples for spectroscopy are made, the chill samples shall be prepared as prescribed in IS : 1817-1961 Methods of Sampling Non-Ferrous Metals for Chemical Analysis. All samples, including the residues of the analysis, shall be retained by the ingot maker or the founder for at least one month after preparation.

5.2 Sand-Castings — Sample or samples shall be taken from the melt after stirring and immediately prior to pouring.

5.3 Gravity and Pressure Die Castings — The sample or samples shall be taken towards or at the end of the pouring.

6. PRODUCTION OF PRESSURE DIE CASTINGS

6.1 Unless otherwise authorized by the inspector, pressure die castings, other than those made by the cold chamber process, shall be produced from approved ingots only.

6.2 For die casting purposes, use of direct scrap shall not be permitted. However, scrap for production of ingots may be permitted.

7. DIMENSIONAL TOLERANCES — CAST MATERIAL OTHER THAN INGOTS

7.1 The thickness of castings where not machined shall be not less than the nominal thickness and shall not exceed it by more than 10 percent, unless otherwise agreed to between the purchaser and the manufacturer. The castings shall be capable of being machined, where required, to the finished dimensions without leaving evidence of the cast surface.

8. FREEDOM FROM DEFECTS

8.1 Ingots

8.1.1 The ingots shall be free from dross, slag or other harmful impurities.

8.2 Castings

8.2.1 The castings shall be clean and sound. They shall be capable of being machined satisfactorily and of taking a good finish.

8.2.2 Defective castings shall be repaired only with the prior consent of the inspector and subject to the conditions laid down by the inspecting authority. Each repair or weld shall be encircled with a ring of white paint prior to submission for final inspection.

8.2.3 Any casting may be rejected for faults of manufacture, defects or incorrectness of the specified dimensions, whether discovered during inspection or subsequently during machining, notwithstanding that the casting had been passed previously as conforming to the chemical composition and mechanical test requirements of the specification.

9. PREPARATION OF TENSILE TEST SAMPLES

9.1 Except as provided in Part II the metal for the test samples shall be taken from the crucible or ladle from which the ingots or castings are cast and shall not be subjected to re-fluxing or to any treatment other than adjustment of the temperature to that suitable for pouring.

Note — When a molten sample to represent ingots is taken from a cast of magnesium base alloy that has been grain refined by zirconium, the manufacturer shall be permitted to add further zirconium to the sample.

9.2 Except as provided in **9.3** and **9.4** test samples shall be cast in sand moulds which shall have internal dimensions of one of the forms *A* or *B* shown in Fig. 1. The mould may be inclined at an angle of approximately 30° from the vertical at the commencement of pouring and the metal shall be poured into the top of the mould. The sand of the mould shall be rammed into any convenient container (such as a steel tube) so that the portion of the bar tapering from 25 mm to 24 mm is separated from the container walls by not less than 25 mm of sand.

NOTE — The temperature of the mould immediately prior to casting shall be between 10° and 40°C.

9.3 Alternatively, at the option of the manufacturer, and where permitted by the relevant specification, the test samples may be produced in a sand mould giving the form *C* shown in Fig 2.

9.4 Alternatively, at the option of the manufacturer, test samples to represent gravity and pressure die castings may be cast in a drill mould giving one of the forms *A*, *B*, *D* or *E* as shown in Fig. 1, 3 and 4, respectively.

NOTE — By agreement between the ingot maker and the founder, chill cast test bars may be used to represent ingots to be used only for the production of gravity or pressure die castings.

9.5 The test samples shall not be mechanically worked before they are tested.

10. TENSILE TEST

10.1 Test pieces shall be machined and tested in accordance with the relevant Indian Standard.

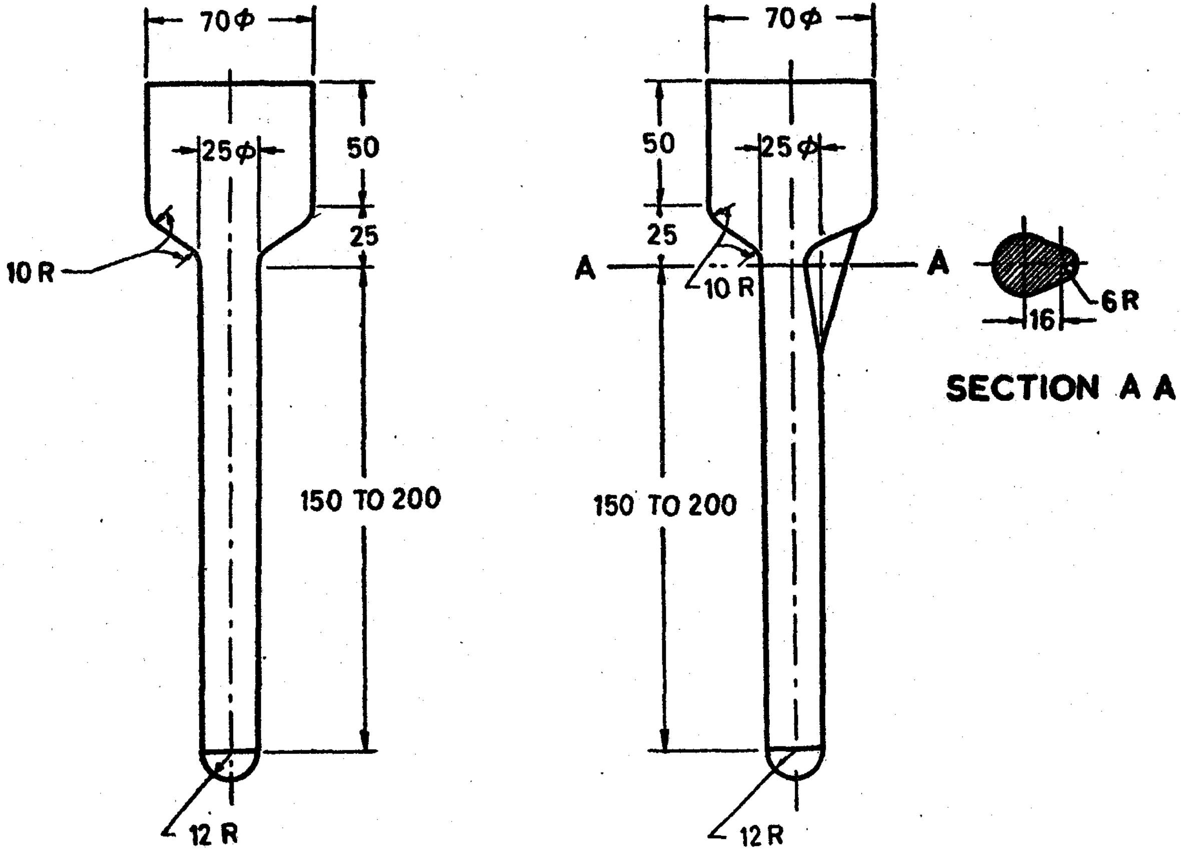
10.2 The test values obtained shall comply with the requirements of the relevant specification.

11. IDENTIFICATION OF INGOTS

11.1 Each aluminium alloy ingot 5 kg in weight and over and each magnesium alloy ingot 2·5 kg in weight and over, passed by the inspector, shall be identified by the mark of the inspector and such other marking as shall ensure full identification of the material.

11.1.1 All aluminium alloy ingots under 5 kg in weight, passed by the inspector, shall be marked in accordance with **11.1** or shall be made into bundles and the necessary marks stamped on a metal lable securely attached to each bundle.

11.2 Each aluminium alloy casting 2·5 kg in weight and over, and each magnesium alloy casting 1·5 kg in weight and over, passed by the inspector, shall be identified by the mark of the inspector and such other marking as shall ensure full identification.

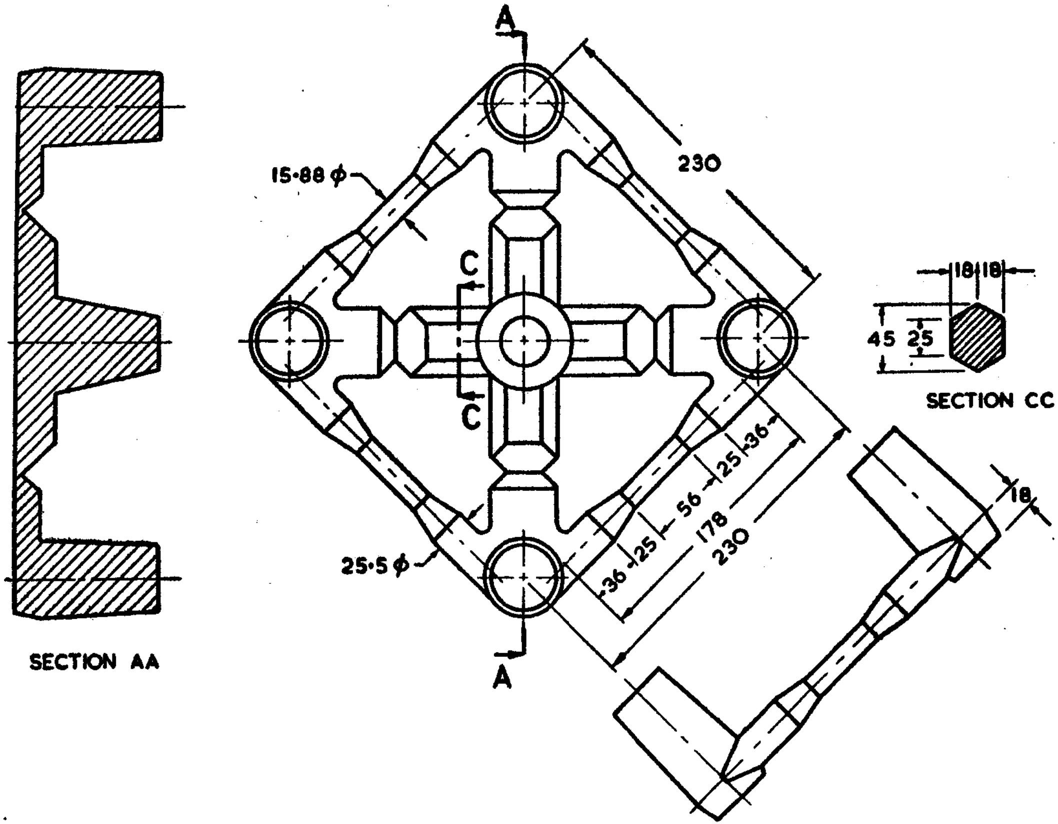


Form A

Form B

(All dimensions in millimetres)

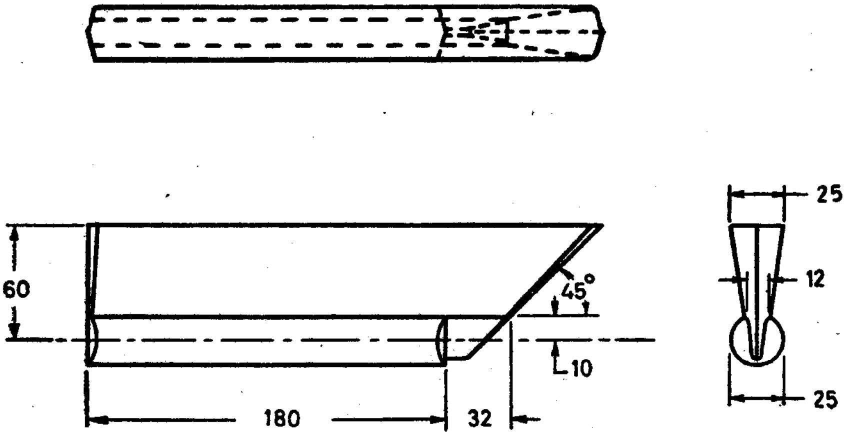
Fig. 1 Sand Cast Test Bars



Form C

(All dimensions in millimetres)

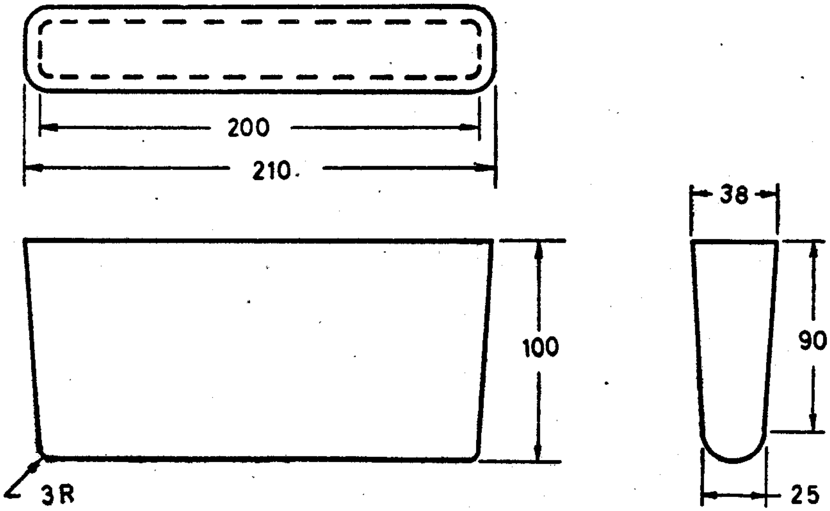
FIG. 2 TENSILE TEST SAMPLE



Form D

(All dimensions in millimetres)

FIG. 3 CHILL-CAST TEST BAR



Form E

(All dimensions in millimetres)

FIG. 4 CHILL-CAST TEST BAR

11.2.1 All aluminium castings under 2·5 kg in weight and all magnesium alloy castings under 1·5 kg in weight, passed by the inspector, shall be stamped in accordance with **12.2** or shall be made into bundles and the necessary marks stamped on a metal lable securely attached to each bundle.

NOTE — The marks shall be applied in such a manner as will cause no detriment to the casting.

PART II APPROVED INGOTS

12. ANALYTICAL REQUIREMENTS

12.1 The chemical composition of the ingots shall comply with the composition specified in the relevant specification or, failing such provision, with the stipulations of the specification for the castings for which the ingots are required.

12.2 The manufacturer shall supply to the inspector, in respect of every cast, the results of analysis for the specified elements.

13. PREPARATION OF TENSILE TEST SAMPLES

13.1 A sample from each cast of alloy shall be cast in accordance with Part I or shall be similarly prepared from re-melted ingots and, where appropriate, shall be heat-treated in accordance with the relevant specification requirements. The test piece machined from this sample shall comply with the tensile test required by the specification.

NOTE — When a molten sample to represent ingots is taken from a cast of magnesium base alloy that has been grain refined by zirconium, the manufacturer shall be permitted to add further zirconium to the sample.

14. RE-TEST PROCEDURES

14.1 If any test piece fails to comply with the specified tensile test, the inspector shall adopt one or both of the following procedures, as requested by the manufacturer:

a) Should any one of the test pieces first selected fail to pass the test, two further samples shall be selected for testing in respect of each failure. Should the test pieces from both these additional samples pass, the material represented by the test samples shall be deemed to comply with the requirements of the test. Should the test pieces from either of these additional samples fail, the material represented by the test samples shall be liable to rejection.

b) With heat-treated alloys, allow the test samples to be re-heat-treated (once only) and re-tested.

PART III CASTINGS MADE FROM APPROVED INGOTS

(Except Aluminium-Silicon Alloys Subject to Modification)

NOTE — The tensile values specified in particular specifications are intended as a test of quality of the material only and may not always be realized in certain portions of castings.

15. MANUFACTURE

15.1 The castings shall be made from approved ingots complying with Part II. Except as provided in **6** approved scrap may be added to the melt at the discretion of the manufacturer.

16. ANALYTICAL REQUIREMENTS

16.1 The manufacturer shall supply to the inspector the results of analysis for the specified elements of not less than 5 percent of the casts of each alloy. The number of analyses shall be subject to a normal maximum of one for each alloy cast during each shift or two for each alloy cast during each day (24 hours), whichever is less, and to a minimum of one analysis per alloy per week.

16.2 The number of analyses required may be increased by the inspector if he is not satisfied with the conditions of manufacture.

17. PREPARATION OF TENSILE TEST SAMPLES

17.1 When a single cast of less than 225 kg is employed, at least one test sample shall be cast and tested to represent the cast (heat-treated in one batch)*.

17.2 When a series of casts of the same alloy each less than 225 kg is employed, at least one test sample shall be cast and tested to represent castings (heat-treated in one batch)* from each 225 kg of metal poured, or, at the option of the manufacturer, each 90 kg of fettled castings (heat-treated in one batch)*.

17.3 When one more casts of 225 kg or over are employed, at least one test sample shall be cast and tested to represent each cast (heat-treated in one batch)*.

17.4 At least one tensile test sample shall be cast for each alloy and tested to represent each day's production of castings.

17.5 If so desired, in the case of special castings, the purchaser may specify at the time of ordering, that one test sample shall be cast and tested to represent each casting.

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*The words in parenthesis are applicable to heat-treated castings only.

18. HEAT-TREATED CASTINGS

18.1 Castings shall be heat-treated in accordance with the relevant specification requirements. Unless otherwise authorized by the inspector each batch of castings shall be heat-treated together with its related test samples provided.

19. RE-TEST PROCEDURES

19.1 If any test piece fails to comply with the specified tensile test, the inspector shall adopt one or both of the following procedures, as requested by the manufacturer:

a) Should any one of the test pieces first selected fail to pass the test, two further samples shall be selected for testing in respect of each failure. Should the test pieces from both these additional samples pass, the material represented by the test samples shall be deemed to comply with the requirements of the test. Should the test pieces from either of these additional samples fail, the material represented by the test samples shall be liable to rejection.

b) With heat-treated alloys, allow the casting or castings to be re-heat-treated (once only) in accordance with **18**, and re-tested in accordance with **19**.

19.2 If both the additional samples tested under **19.1**(a) fail to comply with the specified requirements, the following further re-test procedure shall be applied at the request of the manufacturer and with the consent of the purchaser and inspector:

Test pieces shall be machined from an agreed number of castings. The form, size and location of the test pieces, and the minimum mechanical test values to be obtained from them shall be agreed to between the supplier and the purchaser.

If all the test pieces cut from the selected castings comply with the agreed mechanical test requirements, the castings shall be accepted.

PART IV CASTINGS NOT MADE FROM APPROVED INGOTS

(Except Aluminium-Silicon Alloys Subject to Modification)

NOTE — The tensile values specified in particular specifications are intended as a test of quality of the material only and may not always be realized in certain portions of castings.

20. ANALYTICAL REQUIREMENTS

20.1 Except as provided in **20.2**, the manufacturer shall supply to the inspector the analysis of each cast for the specified elements.

20.2 Where the castings are made wholly from ingots released as complying with **12** (including scrap from such ingots), the manufacturer shall supply to the inspector the results of analyses for the specified elements of not less than 5 percent of the casts of each alloy. The number of analyses shall be subject to a normal maximum of one for each alloy cast during each shift or two for each alloy cast during each day (24 hours) whichever is the less, and to a minimum of one analysis per alloy per week.

20.3 The number of analyses required may be increased by the inspector if he is not satisfied with the conditions of manufacture.

21. PREPARATION OF TENSILE TEST SAMPLES

21.1 At least one test sample shall be cast and tested to represent each cast (heat-treated in one batch)*.

21.2 At least one tensile test sample shall be cast and tested to represent each day's production of castings of each alloy.

21.3 If so desired, in the case of special castings, the purchaser may specify at the time of ordering that one test sample shall be cast and tested to represent each casting.

22. HEAT-TREATED CASTINGS

22.1 Castings shall be heat-treated in accordance with the relevant specification requirements. Unless otherwise authorized by the inspector, each batch of castings shall be heat-treated together with its related sample(s) provided in accordance with the requirements of **21**.

23. RE-TEST PROCEDURES

23.1 If any test piece fails to comply with the specified tensile test, the inspector shall adopt one or both of the following procedures as requested by the manufacturer:

a) Should any one of the test pieces first selected fail to pass the test, two further samples shall be selected for testing in respect of each failure. Should the test pieces from both these additional samples pass, the material represented by the test samples shall be deemed to comply with the requirements of the test. Should the test pieces from either of these additional samples fail, the material represented by the test samples shall be liable to rejection.

---

* The words in parenthesis are applicable to heat-treated castings only.

b) With heat treated alloys, allow the casting or castings to be re-heat-treated (once only) in accordance with **22**, and re-tested in accordance with **23**.

23.2 If both the additional samples tested in **23.1**(a) fail to comply with the specified requirements, the following further re-test procedure shall be applied at the requests of the manufacturer and with the consent of the purchaser and the inspector:

Test pieces shall be machined from an agreed number of castings. The form, size, and location of the test pieces, and the minimum mechanical test values to be obtained from them shall be agreed to between the supplier and the purchaser.

If all the test pieces cut from the selected castings comply with the agreed mechanical test requirements, the castings represented shall be accepted.

PART V ALUMINIUM-SILICON ALLOY CASTINGS SUBJECT TO MODIFICATION TREATMENT, MADE FROM APPROVED INGOTS

NOTE — The tensile values specified in particular specifications are intended as a test of quality of the material only and may not always be realized in certain portions of castings.

24. MANUFACTURE

24.1 The castings shall be made from approved ingots complying with Part II. Except as provided in **6**, approved scrap may be added to the melt at the discretion of the manufacturer.

25. ANALYTICAL REQUIREMENTS

25.1 The manufacturer shall supply to the inspector the results of analysis for the specified elements of not less than 5 percent of the casts of each alloy. The number of analyses shall be subject to a normal maximum of one for each alloy cast during each shift or two for each alloy cast during each day (24 hours), whichever is the less, and to a minimum of one analysis per alloy per week.

25.2 The number of analyses required may be increased by the inspector if he is not satisfied with the conditions of manufacture.

26. PREPARATION OF TENSILE TEST SAMPLES

26.1 The test samples to be provided, as specified below, shall be cast immediately prior to any re-modification of the alloy or, if re-modification is not carried out, they shall be cast after the last casting has been poured. Where test samples are taken to represent a single casting they may be poured first. The metal for the test samples shall be taken from the crucible in which the metal is melted or the ladle from which the castings are poured and shall not be subjected to re-fluxing, further re-modification or to any heat-treatment other than adjustment of the temperature to that suitable for pouring.

26.2 When a single cast of less than 225 kg is employed, at least one test sample shall be cast and tested to represent the cast (heat-treated in one batch)*.

26.3 When a series of casts of the same alloy each less than 225 kg is employed, at least one test sample shall be cast and tested to represent castings (heat-treated in one batch)* from each 225 kg of metal poured or, at the option of the manufacturer, each 90 kg of of fettled castings (heat-treated in one batch)*.

26.4 When one or more casts of 225 kg or over are employed, at least one test sample shall be cast and tested to represent each cast (heat-treated in one batch)*.

26.5 At least one tensile test sample shall be cast for each alloy and tested to represent each day's production of castings.

26.6 If so desired, in the case of special castings, the purchaser may specify at the time of ordering that one test sample shall be cast and tested to represent each casting.

27. RE-TEST PROCEDURES

27.1 If any test piece fails to comply with the specified tensile test, the inspector shall adopt one or both of the following procedures, as requested by the manufacturer:

a) Should any one of the test pieces first selected fail to pass the test, two further samples shall be selected for testing in respect of each failure. Should the test pieces from both these additional samples pass, the material represented by the test samples shall be deemed to comply with the requirements of the test. Should the test pieces from either of these additional samples fail, the material represented by the test samples shall be liable to rejection.

b) With heat-treated alloys, allow the casting or castings to be re-heat-treated (once only) and re-tested.

27.2 If both the additional samples tested under **27.1** (a) fail to comply with the specified requirements, the following further re-test procedure, shall be applied at the request of the manufacturer and with the consent of the purchaser and the inspector:

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*The words in parenthesis are applicable to heat-treated castings only.

> Test pieces shall be machined from an agreed number of castings. The form, size and location of the test pieces, and the minimum mechanical test values to be obtained from them shall be agreed to between the supplier and the purchaser.
>
> If all the test pieces cut from the selected castings comply with the agreed mechanical test requirements, the castings represented shall be accepted.

PART VI ALUMINIUM-SILICON ALLOY CASTINGS SUBJECT TO MODIFICATION TREATMENT, NOT MADE FROM APPROVED INGOTS

NOTE — The tensile values specified in particular specifications are intended as a test of quality of the material only and may not always be realized in certain portions of castings.

28. ANALYTICAL REQUIREMENTS

28.1 Except as provided in **28.2** the manufacturer shall supply to the inspector the analysis of each cast for the specified elements.

28.2 Where the castings are made wholly from ingots released as complying with **12** (including scrap from such ingots), the manufacturer shall supply to the inspector the results of analysis for the specified elements of not less than 5 percent of the casts of each alloy. The number of analyses shall be subject to a normal maximum of one for each alloy cast during each shift or two for each alloy cast during each day (24 hours), whichever is the less, and to a minimum of one analysis per alloy per week.

28.3 The number of analyses required may be increased by the inspector if he is not satisfied with the conditions of manufacture.

29. PREPARATION OF TENSILE TEST SAMPLES

29.1 The test samples to be provided, as specified below, shall be cast immediately prior to any re-modification of the alloy or, if re-modification is not carried out, they shall be cast after the last casting has been poured. When test samples are taken to represent a single casting they may be poured first. The metal for the test samples shall be taken from the crucible in which the metal is melted or the ladle from which the castings are poured and shall not be subjected to re-fluxing, further re-modification or to any heat-treatment other than adjustment of the temperature to that suitable for pouring.

29.2 At least one test sample shall be cast and tested to represent each cast modified in one operation (heat-treated in one batch)*.

29.3 At least one tensile test sample shall be cast and tested to represent each day's production of castings of each alloy.

29.4 If so desired, in the case of special castings, the purchaser may specify at the time of ordering, that one test sample shall be cast and tested to represent each casting.

30. RE-TEST PROCEDURES

30.1 If any test piece fails to comply with the specified tensile test, the inspector shall adopt one or both of the following procedures, as requested by the manufacturer:

a) Should any one of the test pieces first selected fail to pass the test, two further samples shall be selected for testing in respect of each failure. Should the test pieces from both these additional samples pass, the material represented by the test samples shall be deemed to comply with the requirements of the test. Should the test pieces from either of these additional samples fail, the material represented by the test samples shall be liable to rejection.

b) With heat-treated alloys, allow the casting or castings to be re-heat-treated (once only) and re-tested.

30.2 If both the additional samples tested under **30.1**(a) fail to comply with the specified requirements, the following further re-test procedure shall be applied at the request of the manufacturer and with the consent of the purchaser and the inspector:

> Test pieces shall be machined from an agreed number of castings. The form, size and location of the test pieces, and the minimum mechanical test values to be obtained from them shall be agreed to between the manufacturer and the purchaser.
>
> If all the test pieces cut from the selected castings comply with the agreed mechanical test requirements, the castings represented shall be accepted.

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*The words in parenthesis are applicable to heat-treated castings only.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	*Unit*	*Symbol*
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	*Unit*	*Symbol*
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	*Unit*	*Symbol*	*Conversion*
Force	newton	N	1 N = 0·101 972 kgf
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2

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